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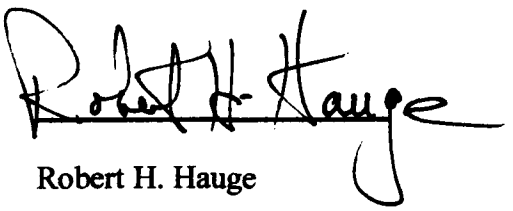

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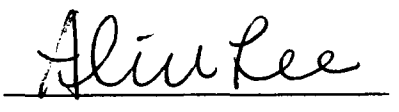

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Design of a Gas-Single Wall Nanotube (SWNT) Interaction Test Module

Final Report
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DESIGN OF A GAS-SWNT INTERACTION TEST MODULE

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Abstract

A gas-SWNT interaction test module was designed and constructed. The purpose of the module is to quantitatively measure the electrical response of SWNTs to a variety of gases. This is accomplished by monitoring the electrical response of a SWNT packed column to specific gases. The apparatus is similar to a gas chromatograph with the difference that the movement of gas is tracked by monitoring the electrical resistivity at the beginning and end of the column. The change in electrical resistivity as a function of the amount of gas injected, the time required to transit the column and their respective dependence on temperature will be documented.

INTRODUCTION

Rice university investigators have led the way with respect to production and characterization of single wall carbon nanotubes. New production methods sponsored by NASA are now coming on line that will dramatically increase the availability and decrease the price of single wall carbon nanotubes. Methods to separate nanotubes by diameter and length are also funded and ongoing at Rice. Thus development of sensor applications that utilize the availability of nanotubes is timely.

Single wall carbon nanotubes are a new material with a very unusual property in that all carbon atoms are surface atoms. Thus anything that adsorbs on the surface will significantly affect the electrical and optical properties of single wall carbon nanotubes. These changes can be monitored such that parts per thousand of a monolayer on the nanotubes are detectable. This translates into parts-per-billion sensitivity for toxic species.

The unique sensitivity of the electrical properties of SWNTs to gas adsorption is expected to lead to the development of sensors that rapidly and continuously detect very low levels of toxic gases such as ammonia, hydrazine, halogens, nitrogen oxides and acids. Measurement of the responsivity of SWNTs to specific concentrations of various gases is needed for evaluation of the potential of SWNTs gas sensors. We have designed and built a gas chromatograph with a unique SWNT column that provides a measure of relative responsivities for various gases. This gas-SWNT interaction test module is described in the following section.

GAS-SWNT TEST MODULE

An intial version of the test module has been built during the summer and is currently being instrumented for controlled gas flow and accurate resistivity measurements. The module consists of a packed column of silica microspheres that have been coated with SWNTs. Surface area measurements were performed on the SWNT material used to make the column. These measurements show that the SWNT materials have a surface area between 300 and 600 square meters per gram. This large surface area makes SWNTs ideal for gas sensing.

A voltage drop is imposed along the column by two electrodes placed at the beginning and end of the column. Additional electrodes with a spacing of approximately one millimeter are placed near the beginning and end of the column to measure resistivity changes as a gas pulse passes through the column. Inert gas is continuously passed through the column in a temperature-controlled environment. Operation involves injecting a sample into the inert gas stream and following the change in conductivity at the beginning of the column and at the end of the column. The time that a gas requires to move through the column, the dependence on column temperature and the smallest detectable amount of gas will be determined for a variety of gases and volatile liquids. .

The test module will be operated jointly with NASA and Rice personnel during the next year. Measurements will be made that allow the prediction of the ultimate sensitivity of sensors that use single wall carbon nanotubes as both the adsorbing and sensing element. These measurements will be used to construct a database characterizing the response of SWNTs to different gases. This database will be utilized to design and qualify SWNT based sensors.